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THE LYMPHATICS OF THE WALLS OF THE LARGER BLOOD-VESSELS AND LYMPHATICS. By GEORGE HOGGAN, M.B. Edin., and FRANCES ELIZABETH HOGGAN, M.D. Zurich, M.K.Q.C.P. Ireland. (PLATE I.)

THE structures which we are about to describe will be found to have most important bearings upon the conceptions now entertained of the physiology of the lymphatic system, as well as upon its anatomy; for none of the functions seriously attributed to it at the present day will be found capable of explaining its existence and relations in the walls of the larger lymphatics, and the only function which, in our opinion, may hypothetically be held to account for its presence there, will also apply equally, in general, throughout the body, giving an additional importance to the lymphatic system.

The presence and peculiar position of the lymphatics within the walls of the larger lymphatics themselves appear, with our present conceptions of the physiology of the system, to be nothing more nor less than an anatomical curiosity. Although the same thing cannot be said of the lymphatics of the walls of arteries and veins, and however great a dissimilarity may, at first sight, appear to exist in the relation of the lymphatics to the different structures which enter into the different coats or layers forming the walls of the three kinds of vessels, we shall be able to recognise with tolerable clearness that the plan of distribution is the same in all three. It is somewhat curious that, notwithstanding the fact that in former days the idea of the existence of lymphatics within vascular walls (and indeed everywhere) had its origin in this country as a hypothetical deduction from certain experiments on animals performed by the Hunters and their successors, that idea having been overthrown, or been supposed to be overthrown, by the experiments performed by Majendie, it has at length disappeared from all the latest English text-books on anatomy and on physiology, as far as we have yet been able to ascertain. Even Carpenter, whose work is supposed to refer to every physiological question under the sun, makes no allusion to this one; and it has been left in these days to Continental writers to keep up the Hunterian legend, and to Continental investigators to demolish the Hunterian hypothesis by applying to it the test of a practical investigation.

Of those who have practically investigated this question, Professor Sappey is certainly the most important, and no more recent authority could be quoted. At page 797 of his *Anatomie Descriptive*, published in 1876, he says:—"The internal membrane of the circulatory apparatus has been considered as a closely serried plexus of lymphatic capillaries. This opinion, emitted by the illustrious Hunter, was published at first by his pupil Cruikshanks, then by Mascagni, and afterwards by a great number of authors. Lauth, by showing such capillaries on the walls of the heart, attracted new partisans to the doctrine. Shortly afterwards, Breschet admitted that the plexus discovered by that anatomist becomes prolonged upon the whole extent of the circulatory apparatus. The employment of the mercurial injection tube, said he, allows us to recognise that the interior of the whole vascular system is formed by lymphatic vessels.

"Proposing to myself to study these vessels, I have explored with the point of the tube the walls of the arteries and veins, fully convinced that I was about to see a plexus of numerous capillaries rapidly display itself at the first juncture. My surprise has been great not to find them anywhere upon the arterial and venous walls belonging to the different parts of the body. I have never been able to see the smallest canaliculi. Other investigators have taken up this research, but with no better result. We may, therefore, admit that the blood-vessels are destitute of lymphatic vessels." To the foregoing we may add, that nowhere in his works can we discover that Sappey makes even the most distant reference to lymphatics within the walls of the larger lymphatic vessels.

Contemporaneously with Sappey's earlier researches into the lymphatic system, we have the writings on this subject of the great French anatomist Cruveilhier, whose opinions, however, seem to be derived more as deductions from hypotheses than as ascertained anatomical facts. The opinions of Cruveilhier on the present question are no exception to his usual practice. At page 120 of the third volume of his *Anatomie Descriptive*, published in 1851, he says:— "We have as yet only partially found the lymphatic network of the internal membrane of the veins and arteries, but the analogy which exists between the internal membrane of the serous surfaces and the internal membrane of these vessels is such, that I have no doubt whatever of the identity of the results as regards the lymphatic plexus. I have, moreover, met with special lymphatics of the aorta, injected with blood, in several cases of alteration of the wall of this vessel." At page 136 he further states :—" Lymphatic vessels of an excessive tenuity, analogous to the vasa vasorum of arteries and veins, probably arise from the walls of the lymphatics."

With reference to these opinions of Cruveilhier, we may at once state that we have never yet seen the slightest vestige of a lymphatic within the intima of arteries or of veins having a muscular coat; and there is every reason to suppose that the lymphatics injected with blood in the aorta were only blood-vessels, and not lymphatics. Further, there is no more tenuity in the lymphatics which, he says, *probably* exist in the lymphatic wall, than in the lymphatics elsewhere in the body.

The German anatomists seem to give little attention to this question, their remarks being evidently borrowed from the French. Henle, in his *Handbuch der Anatomie*, page 407, says :—" Hunter, Mascagni, and Breschet had looked upon the inner membrane of the blood-vessels as a structure rich in lymphatics, and had even described it as consisting of coils of lymphatic vessels. For the intima of the blood and lymphatic vessels this opinion has long ago been given up ; even in connection with the endocardium, their existence has been disputed by Sappey." Eberth, who, with Belajeff, published an account of the lymphatics of the endocardium in Virchow's *Archiv*, repeats the opinion he expressed there, in his article on the blood-vessels, in Stricker's *Handbook*, vol. i. p. 266, as follows :—" Lymphatics have not hitherto been traced into the coats of the blood-vessels. The lymphatics of the endocardium only extend as far as the semi-lunar valves."

In our own country, the latest opinions we have been able to discover, to which any weight can be ascribed, are those of Lane, in the article "Lymphatics," in Todd's *Cyclopædia of Anatomy*. At page 216 he says :—" With respect to the universal network of lymphatics, attributed to the lining membrane of the heart, and to that of the arteries and veins, I cannot admit that the injection of a few minute canals with quicksilver on the lining membrane of the heart of the horse by Lauth, and similar injections by Cruveilhier and Bonamy, can be received as demonstrations." At page 217, with a caution more characteristic of the investigator than of the compiler, he justly states that his own anatomical and physiological investigations lead him to consider that the extent to which the lymphatics are supposed to exist in the organism must be greatly curtailed. He also believes that " anatomists have not yet freed themselves from the influence of the Hunterian views which supposed ubiquity for the lymphatics." An example of the influence which he deprecates, bearing upon the present question, is to be found in a previous volume, under the article " Absorbents," by J. Hart, who gravely infers, from the absorption of blood coagula from within the ends of ligatured arteries, that the presence of absorbents is thereby proved in every part of the arterial system. This is the Hunterian doctrine pure and simple. The disappearance of blood-clot is called absorption. Only lymphatics, he assumes, absorb; therefore, the absorption of blood from the interior of arteries demonstrates the existence of lymphatics on the inner surface of the whole arterial system.

The foregoing remarks, it will be understood, only refer to the intrinsic lymphatics actually within the walls of the blood and lymph vessels, and they have no bearing upon the question of lymphatic sheaths, or of companion lymphatics of blood-vessels. The former are still much believed in at the present day, more especially in connection with the lymphatic sheaths or spaces which are supposed to surround the blood-vessels in the brain. To all statements in regard of the existence of such structures we give an unqualified contradiction. The facts which were supposed to prove them were artificial productions, and already, in our article on the lymphatics of the pancreas,[1] we have explained the cause of such artificial appearances, and described a method by which they may be produced at will under the microscope, where every step in the process may be watched, and the relation of such imitation lymphatics with the real lymphatics made perfectly clear, both of them being demonstrated within the same preparation.

The question of companion lymphatics of blood-vessels, although hitherto left out of consideration in the short historical sketch we have given, has really intimate connection with the present subject. It is only in the walls of the largest blood-vessels that we expect to meet with intrinsic lymphatics; but with a set of smaller veins and artery we often find companion lymphatics, forming, it may be, a more or less open and irregular plexus round the group, as if placed there to drain off excess of fluid escaping from the blood-vessels. This condition becomes even accentuated where no collecting lymphatics lie in the vicinity of the group—a condition which we have explained at some length in our article on the lymphatics of the urinary bladder.[2] As far as their function of drainage is concerned, there is thus intimate resemblance between the extrinsic plexuses now referred to and the intrinsic lymphatics which form the special subject of this paper. It is only when these latter are found on the internal surface of veins and lymphatics that the resemblance ceases, and a new function seems indicated that is unrepresented in the extrinsic or companion lymphatics.

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[1] This *Journal*, July 1881.

[2] *Ibid.*, April 1881.

Before proceeding further, let us give a short account of the method of preparation, and of the structures we have examined. The present study does not pretend to be an inquiry into the comparative anatomy of the lymphatics of vascular walls in many different classes of animals. We are more concerned with establishing the fact of their existence, on account of the bearing it has on the general function, or one particular function, of the lymphatic system; for it must be some function in addition to those of modified absorption, and of a peripheral drainage system, which calls for the existence of intrinsic collecting lymphatics upon the inner surface of the thoracic duct itself. We start with the knowledge that in the smaller vessels of the larger mammals, as in the largest vessels of the smallest mammals, the structures we describe do not exist. We therefore intentionally choose the largest vessels in the largest mammals at our disposal (principally the goat and horse) as the best materials for our research, as in them we are certain to find the lymphatic system at its fullest development, the various tissues forming layers in the vascular walls being most distinct, and the relationship of the lymphatics to the layer most clearly defined.

In the case of every vessel we wish to examine, the use of our histological rings is absolutely necessary.[1] As, moreover, it is necessary to get rid, as much as possible, of the flocculent tissue forming the external coat, or *tunica adventitia*, of the veins and arteries, it is not advisable to dissect these out from the tissues in which they lie buried, but, if strong enough, to tear them out, as by this process the vessels come away, deprived in most cases of this flocculent coat and of the fat cells which are lodged often within it. This is always possible in the case of the systemic arteries and the pulmonary arteries and veins. Elsewhere the smaller veins and largest lymphatics must be dissected out, and the loose fibre and fat cells subsequently removed carefully from their outer surface after they are stretched upon the rings.

[1] *Journal of the Royal Microscopical Society*, July 1879.

Within this adventitia no lymphatics ramify, but they only pass through it to ramify in the solid gelatinous matrix of the wall lying internal to the adventitia, and on the outer surface of a muscular layer, when such exists. The adventitia prevents the passage across it of the solutions of silver and gold used by us to demonstrate the lymphatics; it is therefore necessary to remove it before the solutions are applied. Whether this adventitia be removed by tearing it out, in the case of strong vessels, or picking it away with forceps, in the case of the weaker walls of lymphatics and veins, after these have been stretched upon the rings, the greatest care must be taken not to touch the cleared surface with the fingers lest it be made greasy, and the solutions be thus prevented from acting fairly upon the tissues beneath. The vessels having been removed and slit up with scissors, portions of the wall are placed on the rings, with the internal or endothelial surface of the vessel turned outwards, for the outer surface of the tambourine thus formed. From this surface the endothelium, or lining cells, and the serum are removed by passing the edge of a sharp scalpel lightly across it; if the opposite surface have still any of the adventitia adhering to it, that ought also to be removed by a pair of sharp-pointed forceps. If the tissue is too thick to be transparent under the microscope, as in the case of the aorta of a horse, it is easy to remove either the inner or outer half of the wall, by splitting it off with the point of a sharp scalpel, leaving upon the rings that surface in which it is intended to demonstrate the lymphatics.

The foregoing conditions having been obtained, the rest is very easy. A 2 per cent. solution of nitrate of silver is poured rapidly on and off the surface or surfaces we wish to prepare. After a few minutes' exposure to ordinary light, the tissue is well washed with ordinary water, and a 1 per cent. solution of chloride of gold allowed to remain in contact with one or both surfaces which have been silvered. The whole is then well washed, and the requisite exposure effected in a not too bright light, until, by repeated examination under the microscope, we are able to ascertain whether the preparation is likely to prove successful. When it has attained the requisite development, it is clarified in the usual manner by essential oil or glycerine, and excised and mounted as a permanent preparation.

We have already remarked that, although at first sight the position, distribution, and relationships of the lymphatics in the coats of arteries, veins, and lymphatics respectively may appear to be entirely different, they yet follow one general law in their arrangements; and to understand that general law may prove to be of much more importance than merely noting their different appearance in each of the three structures. To understand it, we must trace the development of these three structures, and the gradual formation of the different tissues which compose them, and which mainly regulate the position and character of the lymphatics within their walls. We must get rid of that artificial division and subdivision into many layers, which is so well calculated to puzzle would-be anatomists, and reduce their description to the simplest form. When we trace the arteries and veins to their most minute or developmentally simplest condition as capillaries, and the main efferent lymphatics to their simplest form of channels of origin, we find their walls constituted only by one thin layer of endothelial cells, hollowed out originally, in the case of the former, by vacuolation, and subsequently enlarging their calibre in all three cases by the interposition of new cells between the cells originally forming the wall. With that layer of endothelium, or lining cells, we may state, once for all, that at no period have the lymphatics any connection whatsoever. As the different vessels increase in size and importance, we find their walls strengthened by the addition, externally, of a thin coating of gelatine, elaborated possibly by the cells forming the wall, as an oyster elaborates the shell around its body. This gelatinous coat forms a very important factor in the present question, inasmuch as within it, as within a hyaline matrix, the muscular elements, with the branched cells, the blood-vessels, lymphatics, and nerve bundles, lie in special relations to each other, according to the character, size, and condition of the various vessels in which they are to be found. That relation seems invariable in the walls of the higher developed vessels of either of the three kinds, and may be shortly stated in order as follows, passing from within outwards:—

1. The endothelium of flat cells lining the inner surface of the wall.

2. A certain thickness of clear gelatinous tissue or matrix, in which lie numerous branched cells, probably wandering cells, which by many anatomists would be called the fixed branched cells of the connective tissue. No blood-vessels or nerves appear in this layer.

3. The muscular coat composed of one, or many, layers of muscle cells, with their nerves and blood capillaries, but destitute, as a rule, of lymphatics.

4. An outer coating of gelatinous tissue, which is the special seat of the lymphatics and of the larger blood-vessels and nerve bundles, and containing many branched cells.

5. The loose gelatinous fibres of the tunica adventitia, which, of all the structures of the body, perhaps best merits the term fibrous tissue. It is composed of a felting of long loose fibres, completely disassociated from each other, and woven at every possible angle to each other around the vessel, from which they may easily be torn off as flocculent bundles. Lying within this feltwork many branched cells and fat cells may be found, but no lymphatics. The lymphatics, with the larger blood-vessels and nerves, pass through it to ramify in the solid matrix of the fourth or outer layer of gelatinous tissue, including everywhere under that head both yellow elastic and white fibrous tissue, which are only modifications of the same substance, and undistinguishable by the silver method of preparation.

In the foregoing scheme, as applied to the larger arteries, which possess intrinsic lymphatics within their walls, the position assigned there to the lymphatics is invariable, just as the coating of muscle cells is invariable, even if modified or unequal in thickness on different parts of the periphery of the same vessel.

In fig. 1 we have an example of the manner in which the efferent lymphatics have their origin, so to speak, in a network of collecting lymphatics lying within the outer layer of gelatine upon the outer surface of the muscular coat. In no case whatever, although we have examined many preparations for it, have we met with lymphatics penetrating the muscular coat, and appearing on its inner surface. This is exactly the contrary of all hypothetical suppositions in the past, as well as of the reputed facts which Sappey has so completely demolished; it is even possible that this absence of lymphatics from the internal portions or layers in the walls of arteries, has some bearing upon the question of atheromatous formation or degeneration in the same locality.

In one respect, this absence of lymphatics from the inner coats of arteries, while they may exist in the outer coats, quite agrees with the general function of peripheral drainage adjuncts, which appears to be the principal use of the lymphatic system throughout the body; but, when this is granted, it only makes more incomprehensible the fact that, in non-muscular portions of the walls of the larger veins and lymphatics, typical collecting lymphatics are often to be found in great profusion, as shown in figs. 5 and 6.

According to the views held at the present day, it would not be so very strange that collecting lymphatics should appear close to the inner surface of arteries, in immediate proximity to a freshly elaborated or purified blood or blood serum on its way from its centres of purification to supply the peripheral elements with nutrition. On the other hand, why, according to the same views, these collecting lymphatics should appear upon the inner surface of veins and lymphatics, close to an exhausted and impure blood or lymph on its way from the periphery to the purifying centres, impeding its progress towards those centres by draining it away from the canals which form its shortest route thither, is sufficiently puzzling. Yet this latter condition everywhere exists. The best explanation of these apparent incongruities is probably an anatomical one, unconnected with the functional conditions we have referred to. In portions of the walls of veins and lymphatics furnished with a muscular layer, or coat, and approximating therefore anatomically to the invariable muscular coat of arteries, we have hitherto failed to find lymphatics on the inner side of such muscular portions of the walls, as if the contractile action of the muscle cells was detrimental to the development or existence of lymphatics between these cells and the fluids upon which they exercise a pressure. At all events, if this be not an explanation, it is an interesting coincidence which deserves to be taken into consideration.

We were early struck with the fact that, while upon one portion of the wall of a large vein or lymphatic the muscular layer would be largely and regularly developed, as at fig. 4, yet, on the opposite point in the periphery of the same vessel-wall, and at the same level, the muscular layer might be altogether wanting, where only innumerable branched cells studded the matrix of gelatine forming the wall external to the endothelium. The change from branched cells to muscle cells was a very gradual one, and there could be little doubt that the one was developed from the other, as numerous instances of such cells undergoing the different stages of change, from the one to the other, were to be seen in our preparations. After careful observation of surrounding circumstances, we seemed to have arrived at the explanation of this difference in the wall of the same vessel, or at all events at one of the explanations of this condition. When a large vein or lymphatic is attached to some solid structure, as, for example, the vena azygos or receptaculum chyli upon the vertebral column, that portion of the wall which is attached or fixed to the column in such a way as to be rendered immovable, and incapable of contraction, would generally be found to be destitute of muscle cells, but to contain innumerable branched cells, as in fig. 3. On the opposite part of the periphery of the same vessel-wall, however, at the same level, that portion of the wall being, so to speak, free to contract or dilate as occasion offered, we generally found a regular layer of large muscle cells, as in fig. 4, as if the very act of continually repeated and interrupted movements had the effect of transforming or developing the branched cells into long fusiform or ribbon-shaped muscle cells or fibres, just as a piece of crystalline malleable iron becomes fibrous by rolling it into bars or drawing it into wires.

In agreement with the foregoing variable conditions in the structure of the walls of veins and lymphatics, we find different arrangements of the lymphatics within the walls. As a general rule, offering few exceptions, the lymphatics do not appear on the inner surface of a muscular layer, when such exists in the walls of veins and lymphatics. We have examined several scores of preparations of the intima, or inner surface of arteries, veins, and lymphatics possessing muscular coats, and in no case have we been able to detect lymphatic vessels there, even when we could see that they existed in great numbers within the gelatinous matrix on the outer side of the muscular coat in the same locality. When, however, no regular muscular layer exists in the wall, as in figs. 3 and 5, we may, by treating both surfaces of the wall with silver solutions, demonstrate collecting lymphatics on the inner surface, and efferent valved lymphatics on the outer surface of the same portion of wall; and, in cases where the wall is thin, we may make the connection between the two divisions of collecting and efferent lymphatics evident. In other cases, where the muscular layer is a thin one, or formed of one thickness of muscle cells, the silver solution may be made to penetrate through that thin layer from the inner surface, so as to make the collecting lymphatics on its outer surface perfectly evident, as in fig. 4, thus supplying the connecting link between non-muscular veins and lymphatic trunks with collecting lymphatics on the inner surface of their walls and the intima of muscular-walled arteries where the collecting lymphatics never appear, and showing both conditions to be consistent with one general plan or rule.

Let us now trace the course of the intrinsic lymphatics, from the point at which they leave the walls of the various vessels, and consequently in a direction contrary to the course of the lymph stream. In most cases, where the vessel, whatever its nature, is external to an organ, the efferent lymphatic or lymphatics of its wall pass off at right angles to that wall, and there join together to form main lymphatics running parallel to the vessel. In the thoracic duct, the intrinsic lymphatics of its wall bear the same relation to it that the blood-vessels of the walls of arteries and veins do to these structures. In other words, the lymphatics of the wall of the thoracic duct are not branches of the duct, and do not open directly into it, as far as we have been able to ascertain, but join lymphatic trunks passing away from that neighbourhood, but which may afterwards join it near its termination, either directly or through the medium of other large trunks taking that course.

In the case of the intrinsic lymphatics of the walls of arteries and veins of solid organs, like the spleen, kidney, lung, &c., the efferent lymphatics form a plexus on the outer surface of the walls, which lies more or less longitudinally along the wall, allowing the lymph and blood streams to run parallel to each other until the blood-vessels lie free of the solid organ, and the lymphatics of their walls are thus enabled to pass off from them and join large lymphatic trunks. In the case of the larger vessels, like the aorta and carotid arteries, the vena cava and jugular veins, the plexus of valved efferent lymphatics is dense and complicated, as shown in figs. 1 and 2. In such vessels the efferent lymphatics lie, as a rule, at right angles to the axis of the vessel, within the outer portion of the outer layer or matrix of gelatinous tissue, and forming frequent anastomoses with each other by means of branches showing great irregularity in size; and when they reach that point in the periphery where they are to leave the wall, they pass at once through the adventitia to join the larger lymphatic trunks which lead the lymph away from that neighbourhood.

When we come to the medium-sized arteries and veins, we no longer find the profuse and intricate plexus of efferent lymphatics seen upon the walls of the larger vessels. One, or at most two efferent lymphatics form part of a group with a nutrient artery, and probably a couple of companion veins, and sometimes a nerve bundle. Such groups are found at intervals along the vessels, with a long space between the groups. In such cases the nutrient artery generally lies in the centre, with a companion vein on each side of it, and external to each vein an efferent lymphatic is found, all lying parallel to each other. Upon each efferent lymphatic a large number of valvular dilatations are seen, close to each other, along the course of the lymphatic. From each of these valvular dilatations a straight valveless collecting lymphatic passes off at right angles to the main efferent lymphatic, away from the group, to meet half-way with the collecting lymphatics belonging to another group, and to form typical gridiron plexuses of collecting lymphatics with these, either external to the muscular layer of the arterial or venous wall or, when the latter possesses no muscular coat, to form a plexus immediately under the endothelium of the inner surface, as in fig. 6. The collecting lymphatics, as they pass off at right angles to the efferent lymphatics, lie, of course, parallel to each other, a disposition similar to that often observed in the lymphatics of striated muscle; where, however, the main efferent lymphatics generally lie across the line of the muscle fibres, and the main collecting lymphatics parallel to these fibres and to each other.[1]

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[1] "Lymphatiques des Muscles Striés," fig. 1, *Journal de l'Anatomie*, Nov. 1879.

The intrinsic efferent lymphatics generally pass off from the wall of the vessel at the point, or side, which is attached to other structures. Thus the efferent lymphatics of the walls of the aorta, vena azygos, and thoracic duct, leave those vessels where they are attached to the vertebral column.

Returning again to the collecting lymphatics, we have already seen that their ultimate relative position on the walls of veins and lymphatic vessels depends on whether these vessels have a layer of muscles or not in their walls. When the muscular layer is present the collecting lymphatics lie external to it, and do not appear on the inner surface, or intima, as it is called. But, when the muscular layer does not exist, the lymphatics may ramify immediately underneath the lining endothelium of the wall. It often happens that only one long, solitary, valveless lymphatic would thus be seen upon the inner surface of the vessel. At another time a large number of such long, solitary, collecting, valveless lymphatics may be seen, at short distances from each other, on the greater portion of the internal surface of the vessel wall. At other times, and especially when the vascular wall was attached to a firm support, a dense gridiron plexus is seen, of which, the plexus shown in fig. 6, from the inner surface of the wall of the vena azygos, where it was attached to the vertebral column, is an example. It is the most dense and complex of the plexuses we have yet met with.

Having now described the appearance and relationships of the intrinsic lymphatics within the vascular walls, we reach the more important question of their function there. Any attempt to solve that question involves an inquiry into the functions hitherto seriously attributed to the lymphatic system, and into the grounds upon which the belief in such functions rests. We say seriously, in the sense that such functions are believed in by investigators themselves, without referring to the hundred and one supposed functions that are advanced continually by theorists in the current medical literature of the day. That the lymphatics have the function of being peripheral drainage adjuncts, we have always insisted on in our previous researches into the lymphatic system, and this is as plainly demonstrated by their anatomical position and relations as anything could well be demonstrated. We have only, however, looked upon this as the one special function of the lymphatic system; and, as far as the walls of arteries, or the walls of veins and lymphatics possessing muscular coats, are concerned, it may be the chief, if not the only, function of the lymphatics found there, to act as drainage adjuncts. On the inner surface of veins and lymphatics, such a function would be out of place, and their presence there must certainly subserve some other purpose than drainage, for there they carry the lymph away from the interior of the vessel, instead of pouring it into it. The only other generally alleged function of the lymphatics is that of specific absorption, and we have therefore to inquire what grounds there may be for attributing such supposed function to the lymphatics, so far indeed as to give them the name of absorbents, a name given on merely hypothetical and mostly erroneous grounds, but often used in preference to the name lymphatic, founded upon the fact that they contain what is called lymph. Before, therefore, we can ascribe to the lymphatics found upon the inner surface of veins and lymphatic trunks the function of absorption, we must inquire what is meant by the term, and how, and for what purpose, it can be performed in such localities.

It is no exaggeration, we believe, to say that thousands of experiments have been performed upon living animals, most of them of a very cruel and painful nature, for the sole purpose of elucidating this one function of absorption, in relation to the lymphatic system. We cannot call to mind that any other function for the lymphatics has ever had victims devoted to it, but they have all been sacrificed to the demonstration of absorption. And yet nothing could be more unsatisfactory, more contradictory, and more worthless, than the results obtained from such experiments. When we come to inquire what they have proved regarding absorption, we find no clear evidence whatever of the vital phenomena, or power of selection, that is generally understood by the term; but almost all experiments have turned on the question, whether absorption is performed by the lymphatics only, or whether it has been shared in or wholly performed by the veins. These two points have been the foundation of the opposite views of two different schools,—

the first, that of Hunter, the second, that of Majendie,—which have wrangled and experimented without stint over these two divisions in the one conception of absorption. Even in the one locality, and in the one division of the lymphatic system in which the function of absorption appears to be clearest, namely, in the lacteals of the intestinal canal, later views and physical experiments point to a process of dialysis to which digestion is merely an indispensable prelude, forming the food into dialysable materials, a view that almost dispenses with a specific function of absorption. Similarly, the presence of fat molecules, blackened by osmic acid, which may be demonstrated between the epithelium covering the villi, is no proof of absorption, for the same blackened fat molecules can be equally well demonstrated between the epithelial cells lining the sweat ducts.

It was upon the intestinal canal and its lymphatics, or lacteals, that Dr. William Hunter and his school performed their experiments, to prove that only the lymphatics, and not the veins, carried away, or absorbed, nutritive lymph, or chyle, from the contents of the intestinal canal.[1] The plan followed by them was first to choose a very patient (*sic*) animal. They first tried dogs, but these were not patient enough, and anæsthetics were unknown. Sheep were found to be more patient, and more satisfactory; but, as stated by John Hunter, the ass was found "to be patient in the greatest degree, and not so large, nor so strong, but that he may be managed." The animal was thrown upon his back in a garden, and his legs tied to four stakes. The abdomen was laid open widely, and a portion of the intestinal canal included between two ligatures. Certain coloured and odoriferous fluids were then injected into the included portion of the canal, and without going more minutely into the various steps, it may be said that the fluids referred to were only found by those experimenters within the lacteals, and never within the veins; hence the Hunters came to the conclusion that absorption was performed only by the lacteals. This was the sole result obtained, but upon that result was built up the most astounding hypotheses, many of which still exist, at the present day, without one iota of actual proof.

It may be observed here that subsequent experimenters, in performing the same experiments, came to the opposite conclusion regarding absorption by the veins; but, for the present, we adhere to Hunter's results, in order to show where they led him and succeeding physiologists in this country.

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[1] John Hunter's *Works*, by Palmer, London, 1835.

We have already referred to the experiment so often repeated by Majendie,[1] in which, after carefully dissecting out, and protecting, the femoral artery and vein in the thigh of a dog, the whole of the tissues and lymphatics of the thigh were cut through, and a poison injected into the severed limb. As the poison soon after killed the animal, it was clear that it must have returned into the system from the severed limb by the veins; "therefore," said Majendie, "this proves that absorption takes place by the veins." It was objected, hypothetically, at the time, that there might be lymphatics within the coats of the blood-vessels themselves, according to Hunter's doctrine, through which absorption might be carried on, and that through such channels the poison had passed which killed the animal. Majendie at once met this by severing artery and vein, and connecting them by a quill, through which the circulation was re-established. Still, however, the result of injection of poison was as before. This is supposed to have established Majendie's proposition, although, in this country, it has often been pointed out that the process of injection necessarily ruptured many blood-vessels, that there was therefore virtually injection into the blood-vessels, and not absorption. Thus, the value of this horrible experiment was simply *nil*.

Another experiment of Majendie's, for the same purpose, has hitherto been considered unanswerable, although the present research at once gives a key to it. He carefully dissected out the jugular vein in a living animal, freeing the vein, for a considerable distance, from the surrounding tissue. He then lifted up the vein and inserted a broad piece of cardboard between it and its former bed. Upon the denuded vein, near the middle of the cardboard, he poured a poisonous solution, which touched no other tissue than the venous wall, and yet the animal died. But if any one would only look at the plexus of lymphatics which lies upon, or within, the wall of the vein, shown in fig. 2, and consider that so many lie within a portion only two millimetres square, there would be little difficulty in proving that Majendie's experiment was worthless as far as the demonstration of non-lymphatic absorption is concerned.

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[1] Majendie, *Précis Elémentaire de Physiologie*, Paris, 1836.

These experiments of Majendie's directly involved the question of the existence of lymphatics within the walls of the veins, and were intended physiologically to overthrow the speculations of Hunter, which had led to his conception of lymphatics within vascular walls; and on that account they have an interesting connection with the subject of the present paper. Of course, as far as the results of the experiments made by either Hunter or Majendie, or by their respective followers, were concerned, the absorption they demonstrated was only a modification of the function of drainage, which we have so often insisted upon.[1] It was a draining off of the chyle from the contents of the intestine that Hunter proved to take place by the lacteals; and Majendie only sought to prove a draining away by the veins of the poisonous fluid which he injected or poured upon the tissue or vein wall. So far, therefore, as the opinions of either school are concerned, they throw no light on the use of the lymphatics in vascular walls, the function of drainage having been already discussed by us as inapplicable, at all events, to the inner surfaces of the walls of lymphatics and veins.

Absorption, as conceived by Hunter, was a very different thing from the absorption which is only a kind of drainage; and the question that next arises is whether the lymphatics of vascular walls can have any relation to the function of absorption as conceived by Hunter, and still adhered to as a doctrine at the present day. The absorption he referred to was a solvent and modelling function, which first seemed to bring solid substances into a soluble form, under which form they were subsequently removed by the lymphatics; and it was in this extreme sense that he applied the term absorbents to the lymphatic system. These vessels, according to him, were the prime agents in the absorption of fat, blood-clot, normal and pathological tissues in general, such as tumours, and even bone itself, either in the necrosed condition or in the alveoli of the jaw whence the teeth had been extracted. The difficulty that presents itself to us in respect of looking for any such absorbent function for the lymphatics of vascular walls is, that we consider that all these examples of absorption we have mentioned, as instanced by Hunter, have no foundation in fact in any one case; and even although we find an aortic aneurism causing so-called absorption of the sternum, or bodies of the vertebræ, we cannot admit for a moment that that has anything to do with the lymphatic system, notwithstanding that the lymphatics are numerous on the healthy aorta. To explain this, let us enumerate some of the examples mentioned by Hunter. The argument used is somewhat as follows:—1. He found that liquids in the intestinal canal were taken into the system by the lacteals only; therefore, he says, the lacteals only, and not the veins, are absorbents. 2. The systemic lymphatics are similar to the lacteals; therefore the whole of the lymphatics are absorbents. 3. All fat, blood-clot, bone, or other normal and pathological tissues which *disappear* from any locality are *absorbed;* and as the lymphatics are the only absorbents, they must have absorbed those tissues. 4. As the substances to be absorbed are found everywhere in the body, therefore the lymphatics must exist in every tissue. 5. (Which relates specially to this research). As blood-clot in a ligatured artery becomes absorbed, the intima, or inner surface of arteries, must be well supplied with absorbents, that is, lymphatics. 6. The lacteals appear to communicate with the cavity of the intestinal canal by means of little mouths (the goblet cells); therefore the lymphatics open by mouths upon all the tissues, and especially upon the serous surfaces of the body, including among these the intima of vascular walls.

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[1] It is possible that the results obtained by both parties were correct, due we might suggest to the different specific density of the fluids employed by either side. If the poisonous solution employed by Majendie was less dense than the serum of the blood within the vein, it would pass into the vein by endosmosis; if denser, the blood serum would pass out into the solution.

It would unduly lengthen out this paper were we to show how each of the tissues mentioned by Hunter becomes absorbed or disappears, by virtue of agencies altogether independent of the lymphatic system. In this sense we have our answer ready for each tissue; but for the present it may be sufficient if we consider only the case of blood-clot, as being entirely pertinent to the present research.

In blood-clot absorption the lymphatics can have no share. No one can imagine that there are any lymphatics within the clot itself, whatever there may be in the tissues surrounding it. In the intima of arteries we have shown that no lymphatics exist, so that when blood-clot becomes absorbed from within the occluded ends of a ligatured artery, it is manifestly impossible that the lymphatics can have had anything to do with it. Where blood has become effused accidentally within the tissues, we have been able to follow the whole process of so-called absorption, or rather of organisation, in its various stages, step by step.[1] We have observed that, some short time after the blood has been effused into the tissues, the wandering cells leave the interior of the clot, and subsequently begin to act upon the clot at its periphery, weaving a sort of feltwork of fibres, forming blood-vessels, &c., parallel to that periphery, until the whole clot is organised. At an early stage the red blood-corpuscles break up, forming an amorphous débris, which appears to be eaten, and thus removed by the wandering cells, for the pigment granules can be observed within them. In the whole of this process of absorption, or organisation, no lymphatics are present, and they could thus take no share in the process.

Granting, therefore, that the Hunterian doctrine of absorption can no longer be assumed for the lymphatics, what function can the lymphatics of the inner surface of veins and lymphatics subserve if neither drainage nor absorption can be shown to be necessary or applicable? We are inclined to suppose that the lymphatics here, as elsewhere, have a large share in the reparative, or healing process, after wounds of the tissues in which they are found, by specially supplying the lymph, the pure plastic material by which wounds unite by first intention. The tissues that are best supplied with lymphatics might therefore naturally be supposed to be the ones in which the healing process most readily takes place. The mere presence of blood in a wound seems to be no help whatever to the healing process, for the red corpuscles ought really to be regarded as foreign bodies, which must themselves be removed, as they are removed from organising blood-clot effused into the tissues, a tedious operation which must greatly complicate the healing process. It is possible that it is on this account that, after a cut of the integument, we find bleeding getting gradually lessened, as if by contraction of the blood capillaries, while finally it stops altogether, and serum, or lymph alone (free from corpuscles), comes from the lymphatics, forms the scab, and heals the wound by first intention. This same hypothesis would explain why in amputation of limbs a skin flap, in which lymphatics are exceedingly plentiful, is of greater value when used without the muscles, in the interior of which lymphatics are rare, although blood capillaries are plentiful. For the same reason, the mesial line or linea semilunaris, being (as we have shown elsewhere)[1] exceedingly well supplied with lymphatics, as compared with other portions of the abdominal wall, would be the line of election for making incisions to lay open the abdominal cavity. White fibrous tissue, it is generally agreed, heals more quickly perhaps than any other tissue in the body, and certainly no other tissue is better supplied with lymphatics, Professor Sappey's opinion notwithstanding.

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[1] "Zur pathologischen Histologie der Schmerzhaften subcutanen Geschwulst," Virchow's *Archiv*, 4th February 1881, p. 237.

The hypothesis which we have just stated, in as far as it is applicable to the blood-vessels, receives a large amount of corroboration from some experimental researches undertaken many years ago by the late Professor Spence, and which therefore at the present time may have here a special interest for the Edinburgh School of Medicine. Professor Spence tied a number of arteries in dogs, which were killed at various intervals after the operation. These tied vessels were afterwards examined, and they showed conditions not only entirely consistent with the anatomical facts which we have described in this paper, but which might have been surely predicted from these facts, if the knowledge of them had preceded the experiments. The experiments were made for the purpose of investigating the changes which take place in the arteries of the human body which have been ligatured for aneurisms; and in order to avoid even the suspicion of warping the sense to suit our own hypothesis, to which a description of the results of these experiments in our own words might be liable, we shall quote *verbatim* a paragraph on this subject from the pen of the late Professor Miller, as found on page 543 of the third edition of his *Principles of Surgery*. Professor Miller says of such ligatured vessels :—

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[1] "Lymphatiques des Muscles Striés," *loc. cit.*

"Plastic exudation is not limited to within the vessel. It occurs, and more extensively, on its exterior, forming a dense swelling of some size, within which the ligature's noose is deeply embedded. The highly important, and even essential character, of this external exudation of plastic fibrin is fully elucidated by the experiments of Mr. Spence, from whose unpublished drawings the illustrations herewith given are derived. He has shown clearly that the internal clot, so far from being, as was supposed by Manec and others, essential to the separation of the ligature without hæmorrhage, is not unfrequently wanting when the vessel has been successfully tied, the closure being entirely effected in these cases by the plastic exudation between the cut edges of the internal coats and by the bulky fibrinous mass within and around the sheath. It is this external exudation which, becoming vascularised, forms the medium whereby blood is supplied from all the surrounding parts to the important new formations within the external coat of the occluded vessel; and which, by its equable pressure upon the divided ends of the internal coats, prevents the tender adhesions within the sheath from being broken up, even when there is no coagulum. According to Mr. Spence, the vessels of the new plastic lymph are formed with great rapidity. In one instance, in the dog, he found them present in considerable numbers sixty hours after the operation. After a longer time, vessels begin to pass even into the clot when this is present; these vessels being always in connection with those of the sheaths and external lymph, and not proceeding, as has been supposed, from the interior of the artery."

Comment on the above description, given for the sake of comparison with the facts which we have discovered, is scarcely necessary. The lymphatics which we have described as ramifying in what is called the outer portion of the middle coat would be completely ruptured in "satisfactory tying," leading to the effusion of their contained lymph only where it has been described as lying. Indeed, the facts being as we have described them, the consequences could not well be otherwise; and the subsequent direction of vascularisation only tends to confirm the hypothesis which we have attached to the lymphatics, in addition to their main function of drainage adjuncts. The whole hypothesis is, however, only put forward tentatively by us, as a means of answering the question propounded by the condition of the lymphatics themselves on the inner surface of the walls of veins and lymphatics. It may be wrong, but if found to be so, another function must be suggested that is distinct both from the drainage function or the absorption which is synonymous with it.

The following conclusions form a summary of the results obtained by us :—

1. No lymphatics exist in the intima or on the inner side of the musculature of large arteries. They ramify in great numbers only within the gelatinous layer lying on the outer surface of the musculature between it and the tunica adventitia.

2. The foregoing conclusion holds good also in the case of the walls of large veins and lymphatics possessing muscular coats.

3. In those portions of the walls of large veins and lymphatics in which the muscular coat is absent, the collecting lymphatics may form a gridiron plexus, with few or no valves, almost immediately underneath the lining endothelium.

4. In all three kinds of vessels the intrinsic efferent lymphatics carry away the collected lymph from off the walls, and do not open into the cavity of any of these vessels.

5. While in the walls of vessels possessing muscular coats the lymphatics seem specially adapted as drainage adjuncts for such vessels, they must have a separate function in the cases of veins and lymphatics, where the collecting lymphatics are found immediately underneath the endothelium. That function is probably to aid in the repair of wounds of the walls of these structures.

DESCRIPTION OF PLATE I.

(*Drawings made by the aid of the Camera Lucida.*)

Fig. 1. Plexus of intrinsic lymphatics lying on the outer surface of the musculature (?) of the aorta of the horse. The upper portion are collecting, the lower efferent lymphatics ($\frac{1}{8}$).

Fig. 2. Plexus of efferent intrinsic lymphatics lying on the outer surface of the musculature of the axillary vein in the horse ($\frac{1}{4}$).

Fig. 3. A portion, *c l*, of fig. 5, greatly magnified, showing part of a plexus of collecting lymphatics lying immediately underneath the lining endothelium of a non-muscular portion of the wall of the receptaculum chyli in the horse ($\frac{1}{110}$).

Fig. 4. A portion of a plexus of collecting lymphatics lying immediately external to a thin muscular layer in the wall of the thoracic duct in the horse ($\frac{1}{110}$).

Fig. 5. Plexus of collecting lymphatics lying amidst the branched cells, and immediately underneath the lining endothelium of a non-muscular portion of the wall of the receptaculum chyli in the horse; *el*, track of an efferent lymphatic seen on the outer surface of the wall ($\frac{1}{10}$).

Fig. 6. Gridiron plexus of collecting lymphatics on the inner surface of a non-muscular portion of the wall of the vena azygos, lying immediately underneath the lining endothelium, from the horse ($\frac{1}{14}$).

a, artery; *c*, branched cells; *cl*, collecting lymphatics; *el*, efferent lymphatics; *m*, muscle cells.

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Fig. 1.

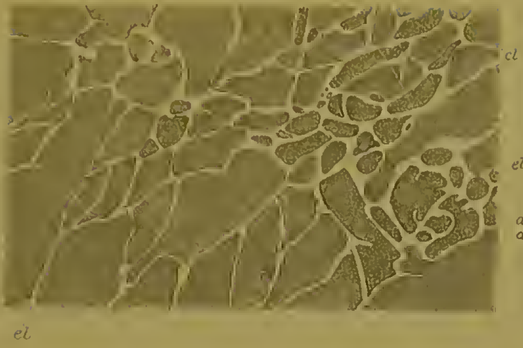


Fig. 2.

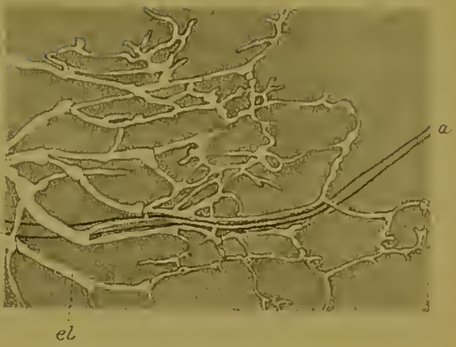


Fig. 3.

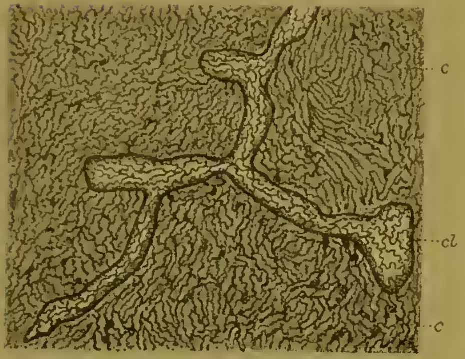


Fig. 4.

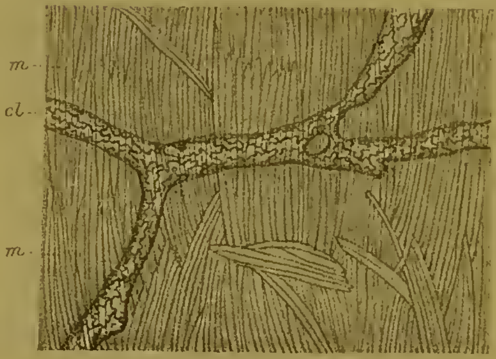


Fig. 5.

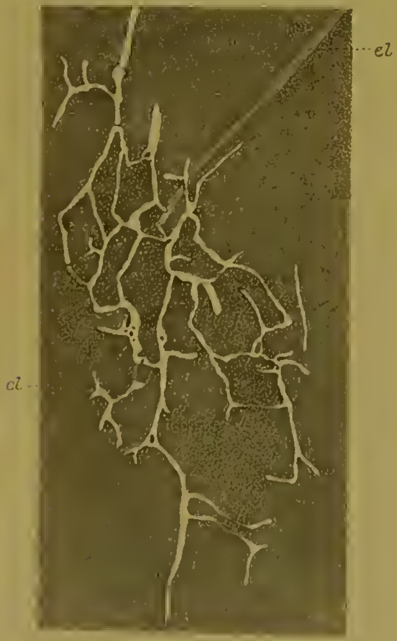
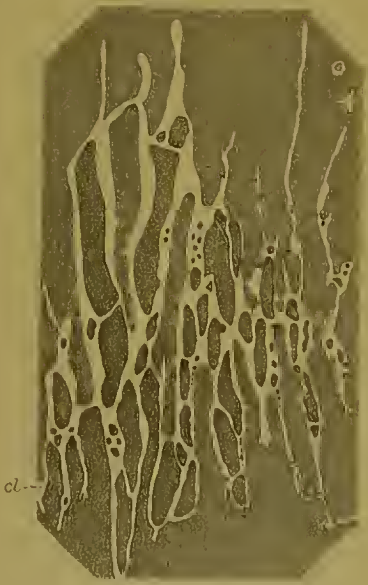


Fig. 6.



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